Investigation of Geological Characteristics of Şanliurfa, SE Turkey by Using GIS

Ahmet Ekmen[1], Ekrem Kalkan[1*]
[1]*Ataturk University, Oltu Earth Sciences Faculty, Geological Engineering Department, Erzurum, Turkey*
[*]*Corresponding author*

***Abstract*—For the geologists investigating the planet's structure, composition and changes over time, it's not always practical to visit a location for field observation. The application of remote sensing in geology means scientists can use electromagnetic radiation to collect detailed information from all over the world. One of the most promising systems for use by earth scientists for applications of the Earth Sciences is the GIS. It, known as a computer based system for mapping and analyzing spatial data, is a tool for working with geographic information. In this study, the GIS has been used to investigate the geological characteristics of Sanliurfa, SE Turkey and its surrounding. By using the GIS, the boundaries of formations belonging to different groups and old and new formations within the current sediments were obtained and the geological map of the region was prepared within the scope of the study. Geological units of the study area consist of Kampanian-Early Marasthihtien age Bozova formation, Eosene-Oligocene Gaziantep formation, Early Miosene age Fırat formation, Late Miosene-Early Pilyosene age Siverek Group, Pilyo-Quaternary deposits and alluvium sediments.**

***Keywords*— Şanlıurfa, Geology, GIS, Geological map, Geo-information**

I. INTRODUCTION

Thegeology has an increasingly important role in protecting the eco-environment and providing land and mineral resources. The various categories of geological survey include: using different methods and different content for geological mapping at various scales, regional geophysical survey, regional geochemical investigation, remote sensing geological survey and evaluation, strategic mineral evaluation, regional environmental geological survey, and marine geological survey. With the development of remote sensing technology, geologists have used these data for mineral identification and mapping, regional mapping, mineral resource exploration, mining environment monitoring, and oil and gas leakage monitoring. Remote sensing is a proven technique that can be confidently and efficiently applied in almost all disciplines of Earth science (Wu et al., 2002; Chipman et al., 2004; Debba et al., 2005; Scheck-Wenderoth and Lamarche, 2005; Huggett, 2007; Curry and Nuon, 2009; Gei et al., 2011; Alanazi and Ghrefat, 2013; Qiang and Hua, 2013; Madani and Niyazi, 2015; Vural et al., 2017; Wu et al., 2018).

The GIS is defined as geographic information systems. The GIS modelling of geological phenomena is a method used to directly represent the abstract concepts of structural shapes and structural relationships of geological features using GIS technology. This is vital for the expression and analysis of geological relationships (Wu et al., 2002; Scheck-WenderothandLamarche, 2005; QiangandHua, 2013). The structural shapes of geological features refer to the geometry features and spatial position features of geological phenomena. Structural relationships of geological features refer to the spatial constituents and the combined forms of geological phenomena, that is, the interior constitution and exterior constitution. This method employs the GIS modelling of the geometrical features of geological structures and their relationships to reveal and visualize the spatial locations and geometries of geological phenomena using dots, lines, planes and other geometric objects (ChengandGong, 2001; Yu et al., 2012; Raiber et al., 2012; Natali et al., 2014; Turner, 2006; He et al., 2018).

The GIS is a system that captures, stores, analyzes, manages, and presents data that are linked to location. It used in cartography, remote sensing, land surveying, photogrammetry, geography, urban planning, emergency management, navigation, and localized search engines (Yarılgaç, 2012). Using the GIS software allows storage of the data in a spatially registered structure and permits cross-referencing for heterogeneous, multidisciplinary data sets. Geographic features such as rivers and lakes or geological features like faults, sample locations, and ages of rocks are all examples of layers. Each layer is independent from the others, yet all have a common geographic registration and they can be linked with each other using specific identification tags. This provides a convenient way of selecting necessary information from the database and making it ready for further analysis and decision-making (Al-Shehab, 2007). Different studies have been carried out to investigate and demonstrate the applications of GIS in Earth Sciences (Elkington et. al., 1997; Jasmi, 1997; Porter, 1997; Brew et al., 2000; Coburn, 2000; Quinlivan, 2000; Stigant, 2000; Aly et al., 2005; Belt et al., 2005)

Many useful GIS modeling approaches have been developed in the field of natural hazards. Rock falls, landslides, floods, avalanches, or soil erosion share inherent characteristics of hazards such as magnitude or spatial extension and depend strongly on slope angle, aspect, or other parameters which can be ideally integrated and displayed in GIS environments (Wilford et al., 2004; Wichmann and Becht, 2006; Gruber and Bartelt, 2007; Lan et al., 2007; Gruber and Mergili, 2013). Hazard assessment using GIS often combines geomorphometric analysis with geostatistical analysis of related parameters to generate models of spatial susceptibility (Huabin et al., 2005; van Westen et al., 2008; Otto et al., 2017).

The objective of this study is to investigate the geological characteristics of the Şanliurfa, SE Turkey and to prepare its geological map. For these purposes, the GIS known as a computer system in which geologically referenced data is entered, managed, analyzed and evaluated was used. The boundaries of the geological units were determined and the geological map of the region was obtained.

II. USE OF GIS IN GEOLOGICAL APPLICATONS

A GIS is a computer system for capturing, storing, checking and displaying data related to positions on Earth's surface. This system can show different kinds of data on one map, such as streets, buildings and vegetation. Although GIS has been around since the 1960s, applications have expanded in the 1990s. Many software systems have now been developed to cover a wide range of fields such as earth and environmental sciences, natural resource management, terrain modeling, agriculture, forestry, construction engineering, land use policy and development control, population distribution, settlement, transport, education, and health planning.

A working GIS integrates five key components: hardware, software, data, people, and methods. The geographic entities are presented as a series of map layers that cover a given map extent. In this system, map layers can view such as roads, rivers, place-names, buildings, political boundaries, surface elevation, and satellite imagery. Geographic elements are portrayed in maps through this series of map layers (Fig. 1).

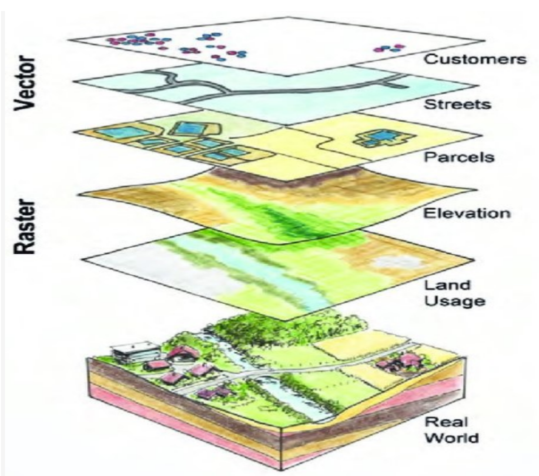

Fig. 1. The spatial elements and phenomena represented as thematic layers in a GIS (Gabathuler et al., 2012)

Various applications have different user requirements based on vendor specifications. Some applications are the reduction of the risk of property damage in settlements, urban planning and modeling, and other socioeconomic applications. Here data layers are transformed by modeling land use dynamics to discover socioeconomic impacts (Ondieki and Murimi, 2009).

III. STUDY AREA

The study area covers the sheet of Şanlıurfa N41-c1 with a scale of 1/25.000. Study area including the center of Sanliurfa and its surrounding is located between the Kızlar Village in the north, ŞanlıurfaEvren Industrial Zone in the southwest and Oğulbey Village in the east. This study has been carried out the area of approximately 151 km^2 (Ekmen, 2019). The location map of study area was given in Fig. 2.

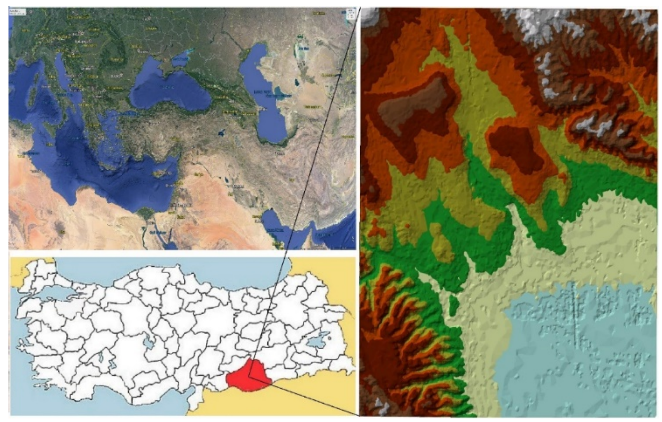

Fig. 2. The location map of study area

In this study, GIS studies were conducted in 4 stages. The data collected during the data collection phase were converted to digital format before being used in GIS. During the data management phase, a database management system was established. this system is a computer software that manages or consolidates databases. In the data processing phase, all this information was converted to the same scale before being merged. This transformation can be temporary for image purposes, or it can be permanent and permanent for an analysis process. At the stage of data presentation, the maps made at the end of many geographical processes were visualized. The geomorphological maps provide the best communication between geographic information and user.

IV. RESULT AND DISCUSSION

Geological units outcroped in the study area consist of marl, clayey limestone, basalts and alluviums (Fig. 3). According to the tectonic findings, the study area is located on the northern side of the Arabian plate going north. As a result of the transgression starting from the Cretaceous, clay, sandstone, conglomerate, limestone and dolomitic limestone were deposited in the area. At the end of the Upper

Cretaceous, the sea deepened as much as possible, forming limestone and clay and inter-banded marls (Ekmen, 2019).

Faulting, volcanism and folding have occurred as a result of the Arabian plate thrust to the north. Sedimentary deposits have a direct connection between the shallow or deepening of the whole area due to tectonic events. The Eocene limestone were terrained in a stable marine environment and the area shifted to terrestrial environment with a possible regression near the end of the Eocene. The Eocene limestone was formed by tectonic movements and formed a rugged appearance. A new transgression begins with Miocene and in the pit areas, the Miocene and its continuing shallow marine or lacustrine environment are followed by Pliocene formations. In the quaternary, dendritic materials originated from lakes and streams (Tardu et al. 1987).

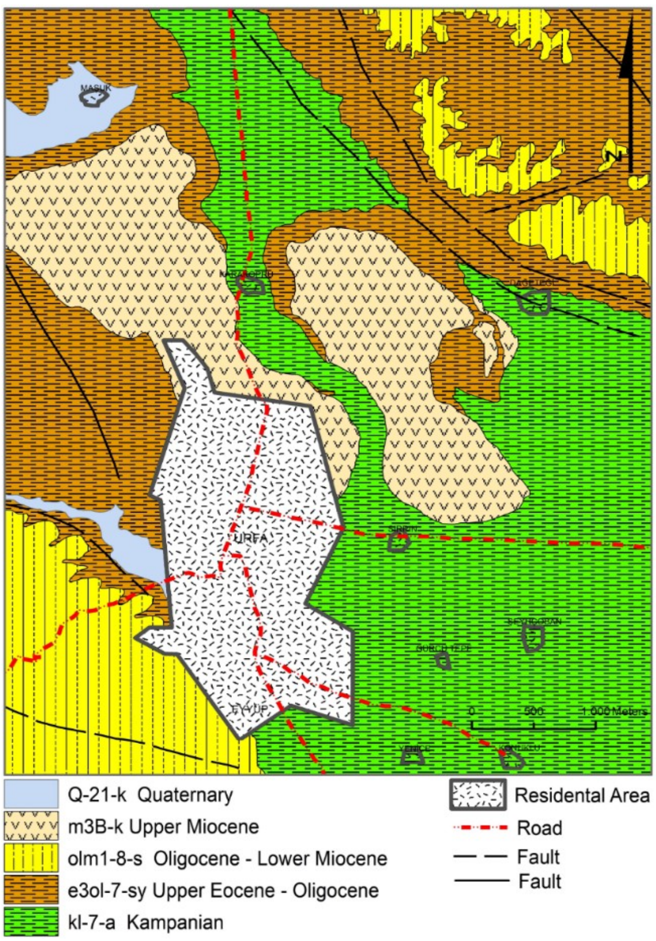

Fig. 3. Geological map of the study area

The oldest unit of the study area consists of Late Campanian-Early Maastrichtian gray, green colored marls (Gossage, 1956). The unit is represented by chalk, cherty marl, clayey limestone, shale, siltstone and sandstone levels and it shows turbiditic character. In the unit, some fossils were obtained such as; *Archaeoblobigerinablowi Pesragno, A. Cretacea* (d'Orbigny) *BiglobigerinellamultispinaLalicher, Contusotruncanacontusa*(Cushman), *C. Fornicata*(Plummer), *C pettersi*(Gondolfi), *Globotruncanitaangulata*(Tilev), *G. Calcarata*(Cushman), *G. Conica*(White), *G stuarti*(de Lapparent), *R pennyiBrönniman, R. Rugosa*(Plummer) *P. Excolata*(Cushman) *Orbitoidesmedius*(d'Arciac) (Çoruh, 1991).

The unit, aged Eocene and Oligocene according to the fossil content, consists of planktonic limestones with medium-thin-thick bedded and brittle benthic foraminifera. The unit continue with thin-medium bedded chalk and phosphate clayey limestone with cream-*white* colored and fine shell fragments. Its fossil content is *A. Bullborki (Bolli), A. Pentacamerata*(Subbotina), *A wilcoxensis, A. Soldadoen-sis* (Brönnimann), *Globigerina ampliaperuta, G. corpulenta, G. lineperta*(Finlay), *Globigerinathekakuglori*(Bolli, Loeblich and Tappan), *Morozovellaaragonensis*(Nuttal), *M. formosagracilis*(Bolli), *M. lehneri*(Cushman and Jaris), *M. subbotinae (Morozova), Truncorotaloidesrohri*(Bronnimann and Bermudez), *T. Topilensis*(Cushman), *Turborotaliacerroazulensiscerroazulensis*(Cole), *T. İncrebescens*(Bandy), *AlveolinapasticilataSchwoger, Assilnaexponens*(Sowerby), *Chapmaninapassinensis*(Sivestri), *Astigerinarotula*(Kaufmann), *Lepidocyclina sp*. (Duran et al., 1988; Duran et al., 1989).

The sedimentary unit, composed of fossilized limestone *with beige*, gray, cream, light gray colored, was named as Fırat Formation by Peksü (1969).The unit is generally composed of massive, medium-thick bedded, sparsely thin bedded, abundant algae, corals, echinides, mollusc shells and benthic foraminiferal limestone. Its fossil content is *Amphistegina cf. lessoni (*d'Orbigny), *Borelismelocurdica*(Reichel), *Elphidiumcrispum*(Linne), *Lepidocyclina cf. parvaOppenoorth, Miogypsinaglobulina*(Michelotti), *M. Mediterranea Brönnimann, M. cf. intermedia Drooger, MiolepidocyclinaburdigalensisGümbel, Operculinacomplanata Defrance, Brannimann Victoriella sp., Anomalina sp., Lepidocyclina*(Eulepidina) *sp., Lepidocyclina*(Nephrolepidina) *sp. (Çoruh et al., 1997).*

The basaltic lava and pyroclastic rocks related to the first phase of Karacadağvolcanics were *defined as* Siverek Group by Er*can* et al. (1991).The unit consists of basaltic lava and proclastic rocks. The basalts are olivine, olivine-augite basalt type basalts and have porphyritic textured, occasionally gas hollow and fhenocrystals forming augite, olivine and plagioclases (Ercan et al., 1991). Pyroclastic rocks consisting of tuff, tuffite and agglomerate occupy less space in the unit and are mostly observed around the volcanic outlet centers.

The youngest geological unit of the study area is alluvial materials. Along the Harran Plain on the southeast side of the study area, there are alluvial plains, pebbles on the surface of the river, thick sand piles and modern alluvial deposits are shows the spread.

In this study, thematic maps and satellite images produced by GIS were used to differentiate between current sediments and other geological units, to obtain maximum efficiency in geological mapping and to minimize error rate. In order to determine the geology of the study area, geological units were separated by using satellite images before field studies. A lot of data was used for visual interpretation and these were stored in GIS environment as raster and vector data. With the image, each of these data is overlapped as a separate layer and the fields of the current units are tried to be determined.

Different color tones were used to differentiate the volcanic and sedimentary units in the satellite images. Morphological features, artificial elements, color and vegetation were used in the formation of geological distinction. When the geological map obtained by the GIS study is examined, it is seen that the geology of the study area is composed of volcanicrocks, sedimentary units and current sediments (Fig. 4).

Although there are different approaches to the lighting angles used in embossment maps, it is known that the lighting directions that change every 90 degrees (azimuth; 45°, 135°, 225° and 315°) give good results (Süzen, 2012). When creating a linearity analysis map of the study area, a fault was drawn on the relief map. Because the fault was only the element of linearity in the study area.

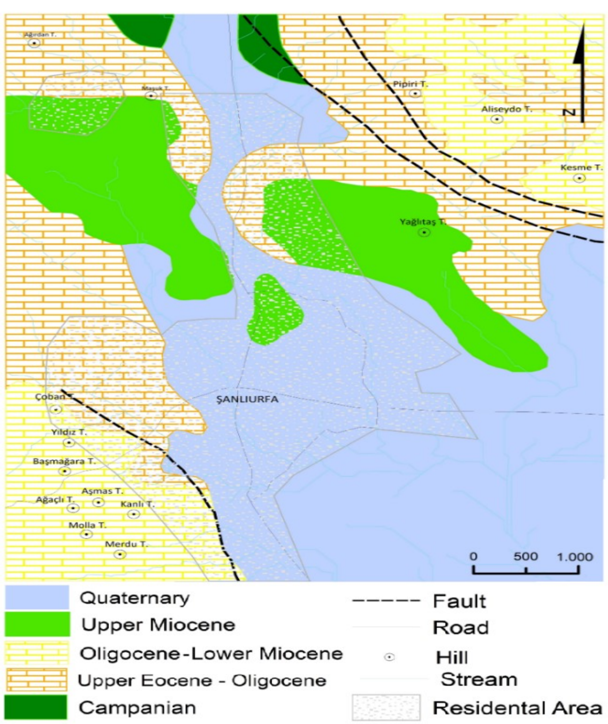

Fig. 4. Geological map of the study area obtained from GIS studies

VI. CONCLUSION

The GIS modelling of geological phenomena is a method used to directly represent the abstract concepts of structural shapes and structural relationships of geological features using GIS technology. The GIS known as a computer system in which geologically referenced data is entered, managed, analyzed and evaluated was used to obtain geological properties and to prepare the geological map of the Şanliurfa (SE Turkey). When the geological map obtained by the GIS study is examined, it is seen that the geology of the study area is composed of volcanic materials, sedimentary units and modern sedimentary deposits.

REFERENCES

[1] Alanazi, H.A., Ghrefat, H.A., 2013. Spectral Analysis of Multispectral Landsat 7 ETM + and ASTER Data for Mapping Land Cover at QurayahSabkha, Northern Saudi Arabia. Journal of the Indian Society of Remote Sensing 41(4), 833-844.

[2] Al-Shehab, A.A., 2007. Applications of GIS in Geology. CRP 514: Introduction to GIS.

[3] Aly, M.H., Giardino, J.R., Klein, A.G., 2005. Suitability Assessment for New Minia City, Egypt: A GIS Approach to Engineering Geology. Environmental & Engineering Geoscience XI, 259-269.

[4] Belt, K., Paxton, S.T., 2005. GIS as an Aid to Visualizing and Mapping Geology and Rock Properties in Regions of Subtle Topography. GSA Bulletin 117, 149-160.

[5] Brew, G., Barazangi, M., Sawaf, T., Al-Maleh, K., 2000. Tectonic map and geologic evolution of Syria: The role of GIS. The Leading Edge, 176-182.

[6] Cheng, P., Gong, J., 2001. Design of three-dimensional spatial data model and its data structure in geological exploration engineering. ActaGeod. Cartogr. Sin. 1, 74-81.

[7] Chipman, J.W., Lillesand, T.M., Schmaltz, J.E., Leale, J.E., Nordheim, M.J., 2004. Mapping lake water clarity with Landsat images in Wisconsin, U.S.A. Canadian Journal of Remote Sensing. 30(1), 1-7.

[8] Coburn, T.C., 2000. On the implementation of GIS for petroleum exploration and development: Issues and perspectives, in T.C. Coburn and J.M. Yarus, eds., Geographic Information System in petroleum exploration and development. AAPG Computer Applications in Geology 4, 61-68.

[9] Curry, A.M., Nuon, H., 2009. Fundamentals of Geomorphology. Royal University of Phnom Penh, Phnom Penh. (700 pp, Khmer).

[10] Çoruh, T., 1991. Adıyamancivarında (XI. Bölgekuzeybatısıve XII. Bölge) yüzeylenenKampaniyen-Tanesiyenistifininbiyostratigrafisivepaleocoğrafikevrimi. TürkiyePetrolleriAnonimOrtaklığıGenelMüdürlüğüRapor No: 1656, 101 (in Turkish).

[11] Debba, P., Ruitenbeek, F.J.A.V., Meer, F.D.V.D., Carranza, E.J.M., Stein, A., 2005. Optimal field sampling for targeting minerals using hyperspectral data. Photogrammetric Engineering & Remote Sensing. 99(4), 373-386.

[12] Duran, O., Şemşir, D., Sezgin, İ., Perinçek, D., 1988. GüneydoğuAnadolu' da MidyatveSilvangruplarınınstratigrafisi, sedimentolojisive petrol potansiyeli. Türkiye Petrol JeologlarıDerneğiBülteni I/2, 99-126 (in Turkish).

[13] Duran, O., Şemşir, D., Sezgin, İ., Perinçek, D., 1989. GüneydoğuAnadolu' da MidyatveSilvangruplarınınstratigrafisi, sedimantolojisivepaleocoğrafyası, paleontolojisi, jeolojitarihi, rezervuarvediyajenezözellikleriveolası petrol potansiyeli. TürkiyePetrolleriAnonimOrtaklığıGenelMüdürlüğüRapor No: 2563, p. 78 (in Turkish).

[14] Ekmen, A., 2019. Investigation of Geological and Morphological Characteristics of Şanlıurfa Province by Using Geographical

Information Systems (GIS). Master's Thesis. Atatürk University, Graduate School of Natural and Applied Sciences, Erzurum, Turkey.

[15] Elkington, G., Lansley R.M., Martin, F., Utech, R., 1997. Uses of GIS data in 3D seismic design and acquisition. Geophysics, 957-959.

[16] Ercan, T., Şaroğlu, F., Turhan, Matsuda, J.J., Ui, T., Fujitani, T., Notsu, K., Bağırsakçı, S., Aktimur, S., Can, B., Emre, Ö., Akçay, A.E., Manav, E., Gürler, H., 1991. Karacadağvolkanitlerininjeolojisivepetrolojisi. TürkiyeJeolojiKurultayıBülteni 6, 118-133 (in Turkish).

[17] Gabathuler, E., Eckert, S., Ehrensperger, A., Bachmann, F., 2012. Mapping and Geoprocessing Tools in Support of Rural Advisory Systems. Margraf Publishers GmbH, 2012 Kanalstr. 21, P.O. Box 1205 D-97990 Weikersheim.

[18] Gei, C., Taubenbck, H., Wurm, M., Esch, T., Nast, M., 2011. Remote Sensing-Based Characterization of Settlement Structures for Assessing Local Potential of District Heat. Remote Sensing. 3(7), 1447-1471.

[19] Gossage, D.W., 1956. Compiled progress report on the geology of part of Petroleum District VI, Southeast Turkey. N. V. Turkse Shell, Report No: GRt. 2,22 p.

[20] Gruber, U., Bartelt, P., 2007. Snow avalanche hazard modelling of large areas using shallow water numerical methods and GIS. Environmental Modelling & Software 22, 1472-1481.

[21] Gruber, F.E., Mergili, M., 2013. Regional-scale analysis of high-mountain multi-hazard and risk indicators in the Pamir (Tajikistan) with GRASS GIS. Natural Hazards and Earth System Sciences 13, 2779-2796.

[22] He, H., Hu, D., Lü, G., 2018. GIS Application to Regional Geological Structure Relationship Modelling Considering Semantics. International Journal of Geo-Information 7, 267.

[23] Huabin, W., Gangjun, L., Weiya, X., Gonghui, W., 2005. GIS-based landslide hazard assessment: an overview. Progress in Physical Geography 29, 548-567.

[24] Huggett, R.J., 2007. Fundamentals of Geomorphology (Routledge Fundamentals of Physical Geography) Second Ed., Taylor and Francis Group, New York.

[25] Jasmi, A.T., 1997. Slope instability and Hazard Zonation mapping using Remote sensing data and GIS techniques in the area of Cameron Highlands, Malaysia, ACRS.

[26] Lan, H., Derek, M.C., Lim, C.H., 2007. Rock Fall analyst: a GIS extension for three-dimensional and spatially distributed rock fall hazard modeling. Computers & Geosciences 33. 262-279.

[27] Madani, A., Niyazi, B., 2015. Groundwater potential mapping using remote sensing techniques and weights of evidence GIS model: a case study from WadiYalamlam basin, Makkah Province, Western Saudi Arabia. Environmental Earth Sciences 74(6), 1-14.

[28] Natali, M., Klausen, T.G., Patel, D., 2014. Sketch-based modelling and visualization of geological deposition. Comput. Geosci. 67, 40-48.

[29] Ondieki, C.M., Murimi, S.K., 2009. Environmental Monitoring Volume II - Applications of Geographic Information Systems-Encyclopedia of Life Support Systems (EOLSS) Applications of Geographic Information Systems, Kenyatta University, Kenya.

[30] Otto, J.C., Prasicek, G., Blothe, J., Schrot, L., 2017. GIS Applications in Geomorphology. In book: Reference Module in Earth Systems and Environmental Sciences.

[31] Porter, T.R., 1997. Exploration GIS: optimizing 3D land operations. The Leading Edge, 121-122.

[32] Qiang, W., Hua, X., 2013. Three-dimensional geological modeling and its application in digital mine. Sci. China Earth Sci. 43, 1996-2006.

[33] Quinlivan, W.F., 2000. Integration issues in E&P spatial data processing. The Leading Edge, 172-175.

[34] Raiber, M., White, P.A., Daughney, C.J., Tschritter, C., Davidson, P., Bainbridge, S.E., 2012. Three-dimensional geological modelling and multivariate statistical analysis of water chemistry data to analyse and visualize aquifer structure and groundwater composition in the Wairau Plain, Marlborough District, New Zealand. Journal of Hydrology 436, 13-34.

[35] Scheck-Wenderoth, M., Lamarche, J., 2005. Crustal memory and basin evolution in the Central European Basin System-New insights from a 3D structural model. Tectonophysics 397, 143-165.

[36] Stigant, J.P., 2000. The impact of geodesy and GPS on GIS data management in international oilfield operations. The Leading Edge, 168-171.

[37] Süzen, M.L., 2012. Sözlüveyazılıgörüşme. UzaktanAlgılamaveCoğrafiBilgiSistemleriLaboratuarıJeolojiMühendisliğiBölümü, OrtaDoğuTeknikÜniversitesi (ODTÜ), Ankara (in Turkish).

[38] Tardu, T., Baskurt, T., Güven, A., Us, E., Dinçer, A., Tuna, M.E., Tezcan, U.S., 1987. AkçakaleGrabenininYapısalStratigrafikÖzelliklerive Petrol Potansiyeli. TürkiyeVII. Petrol KongresiBild. Kitabı, 36-49, Ankara (in Turkish).

[39] Turner, A.K., 2006. Challenges and trends for geological modelling and visualisation. Bull. Eng. Geol. Environ. 65, 109-127.

[40] van Westen, C.J., Castellanos, E., Kuriakose, S.L., 2008. Spatial data for landslide susceptibility, hazard, and vulnerability assessment: an overview. Engineering Geology 102, 112-131.

[41] Vural, A., Corumluoglu, O., Asri, I., 2017. Remote sensing technique for capturing and exploration of mineral deposit sites in Gumushanemetallogenic province, NE Turkey. Journal of the Geological Society of India 90(5), 628-633.

[42] Wichmann, V., Becht, M., 2006. Rockfall modelling: methods and model application in an Alpine basin. Göttingen: Goltze.

[43] Wilford, D.J., Sakals, M.E., Innes, J.L., Sidle R.C., Bergerud, W.A., 2004. Recognition of debris flow, debris flood and flood hazard through watershed morphometrics. Landslides 1, 61-66.

[44] Wu, C., Li, X., Chen, W., 2018. A Review of Geological Applications of High-spatialresolution Remote Sensing Data. *Preprints* 2018, 2018110162 (doi: 10.20944/preprints201811.0162.v1).

[45] Wu, L., Zhang, R., Qi, Y., 2002. 3D geoscience modelling and virtual mine system. ActaGeod. Cartogr. Sin. 2 (1), 28-33.

[46] Yarılgaç, T. 2012. CoğrafiBilgiSistemlerinin (CBS) meyveyetiştiriciliğindekullanımı. OrduÜniversitesiBilimveTeknolojiDergisi. 2 (1), 71-80 (in Turkish).

[47] Yu, J., Wu, L., Zi, G., Guo, Z., 2012. SDOG-based multi-scale 3D modeling and visualization on global lithosphere. Sci. China Earth Sci. 5, 755-763.